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Organic Matter Content of Soil After Logging of Fir and Redwood Forests

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Organic matter in soil controls a variety of soil properties. A study in Humboldt County, California, evaluated changes in percentages of organic matter in soil as a function of time after timber harvest and soil depth in fir and redwood forests. To assess organic matter content, samples were taken from cutblocks of various ages in soil to depths of 1.33 m. Results indicate that only depth correlated significantly with organic matter in the fir forest. Depth, and to a minor extent, age, con-elated significantly with organic matter content in the redwood forest. Organic matter content-in the redwood forest showed a small decline until 35 to 45 years after logging. These findings suggest that the adverse impact on soil organic matter due to logging is minor.

Retrieval Terms: logging effects; organic soil materials; cutover forests; mixed-conifer forests; redwood forests; Humboldt County, California

Organic matter influences physical and chemical properties of soil often to a critical extent. By promoting aggregation, soil organic matter affects erodibility,[1] infiltration,[2] water retention,[3] and shear strength of soil.[4] Organic matter is essential to coarse-grained materials for providing nitrogen and higher cation exchange capacities. This source of nitrogen can decisively affect forest regeneration.[5]

Because organic matter is a necessary and vital soil constituent, the effect of logging on the amount of soil organic matter needs to be assessed. Previous work has shown that slash burning reduces organic matter in surface soil[6] and that increasingly heavy timber cutting reduces the thickness of the surface humus layer.[7] Although several studies have focused on organic matter of the forest floor, subsurface organic matter rarely has been evaluated.

Organic matter is added to a forest soil in a variety of ways. The most recognized method is by decomposition of litter.[8] Other ways include root exudation from trees,[9] and the growth and decay of roots.[10]

I conducted a study in fir and redwood forests of Humboldt County, California, to determine if significant changes in subsurface organic matter content occurred after logging as old roots decomposed and new roots grew. Soil samples were collected from cutblocks of various ages in soil to a depth of 1.33 m. Percent organic matter was determined and the data analyzed and evaluated for changes in amount of organic matter related to time after cutting.

This study shows that soil organic matter in the redwood forest investigated had a small decline and recovery after logging whereas changes in organic matter in the fir forest after logging were insignificant. For the resource manager, this suggests that the adverse impact on organic matter of soil due to logging is minimal.

STUDY SITES AND METHODS

Two areas were selected for study. One was in the fir type on the Six Rivers National Forest of eastern Humboldt County, California; the other was in redwood on private lands of western Humboldt County (*fig. 1*).

The fir type in a mixed-conifer zone includes Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), white fir (*Abies concolor* [Gord. & Glend.] Lindl. ex Hildebr.), red fir (*Abies magnifica* A. Murr.) and assorted minor species. The sampling sites are in silt or clay loams of the Tish Tang or Strawberry soil series. This study area is underlain by the Ironside Mountain Batholith, an igneous intrusion of intermediate composition. Elevations of the sites range from 1250 to 1590 m, with slopes ranging from 0 to 5 percent. Average annual precipitation is from 125 to 150 cm. The area experiences warm summer temperatures (20º to 30ºC) and cold (-6º to 4ºC), snowy winters. The samples were collected in 1975

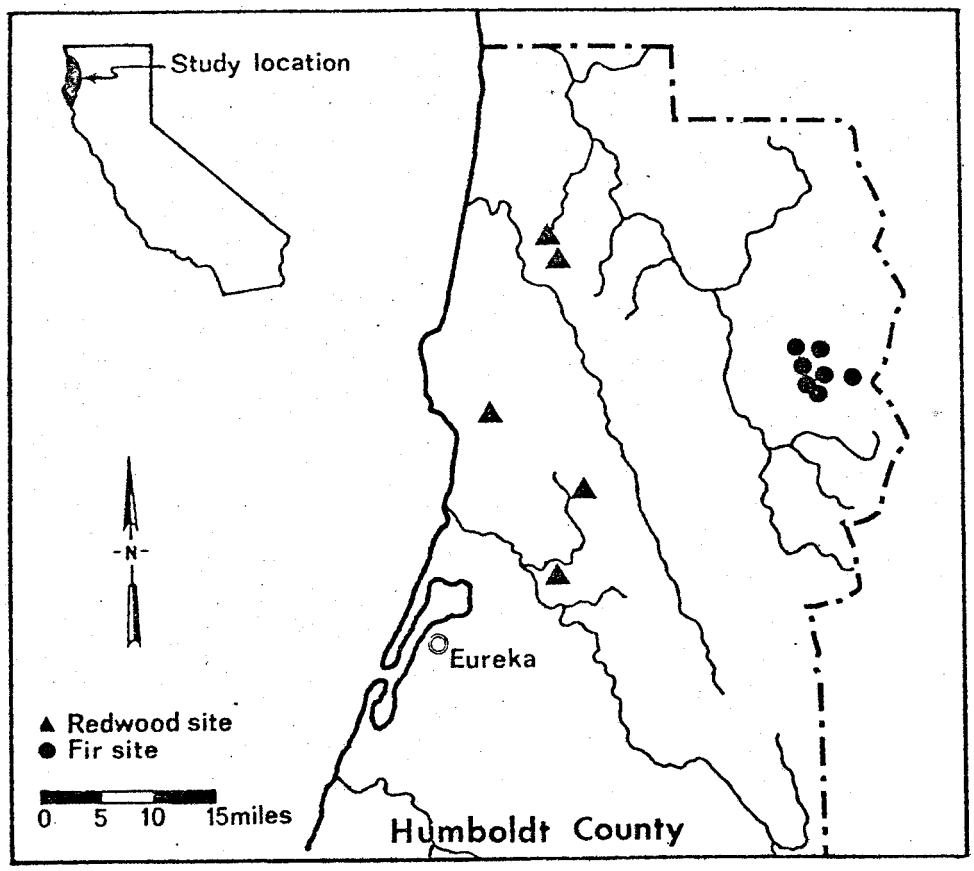

Figure 1—Soil samples were collected from a mixed-conifer forest on the Six Rivers National Forest, eastern Humboldt County, California, and from redwood sites scattered in western Humboldt County, California.

and included clearcuts from the years: 1951, 1955, 1963, 1968, and 1972.

The redwood sites were more scattered in order to sample from clearcuts over a period of 65 years. The dominant tree is redwood (*Sequoia sempervirens* [D. Don] Endl.), and the soil is of the Melbourne or Hugo series. The textures are loam with an underlying bedrock of graywacke from the Franciscan Formation. Elevations range from 180 to 580 m, with slopes ranging from 2 to 42 percent. Average annual precipitation is from 150 to 200 cm and falls predominantly in winter. Temperatures are moderated by marine influences throughout the year. The sites sampled in 1975 had been logged in 1910, 1932, 1951, 1964, and 1970.

Samples of soil organic matter were collected as holes were dug for a root-biomass study. Three or four sampling sites were scattered around a specific cutblock. Sites with stumps were avoided; the least disturbed sites were favored. All slash and litter were cleared away and an access pit 1 by 2 m was dug to a depth of 1.33 m. Samples were taken from holes around the access pit at the mineral surface and at 0.33-m increments to a depth of 1.33 m.

Soil samples were taken to the laboratory, oven-dried at 105ºC, sieved to remove fractions greater than 2 mm in size, and stored in moistureproof bags. Only one set of samples, taken vertically, was randomly selected for analysis from each group of holes to promote independence between samples. A second set was collected from the opposite end of the pit for age classes that were poorly represented. A total of 90 samples were analyzed from the fir zone and 126 from the redwood zone. The procedure described by Ball[11] was used to determine the organic matter by burning 5 g soil in a muffle furnace at 375°C for 16 h before treasuring weight loss. This procedure allows a large number of samples to be tested easily, does not remove the interlayer water from clays, and is suitable for assessing relative differences between samples.

A multiple regression computer program (BMDP P9R[12]) identified the best model for predicting percent soil organic matter from depth, age, and their log and square transformations. This program uses a regression technique that considers all possible subsets of the independent variables. The Mallows' Cp[13] value was used to select the best subset.

RESULTS AND DISCUSSION

The best model for redwood is based on five variables as opposed to two for fir (*figs. 2 and 3*).

Redwood

Percent organic matter =
5.2 - 5.3 depth + 2.2 depth^2 - 0.05 age + 0.0006 age^2 - 0.27 log depth

Fir

Percent organic matter = 3.2 - 0.98 depth - 0.91 log depth

	R^2	Degrees of freedom	Standard error of estimate (percent)
Redwood	0.80	120	0.84
Fir	0.75	87	1.07

The predictive models indicate that time after logging had an insignificant influence on soil organic matter in the fir zone and was significant (95 percent level) in the redwood type. Depth was the dominant factor controlling the amount of soil organic matter and the log of depth was the best single predictor for both areas. The models of depth and log depth show that the quantity of organic matter rela-

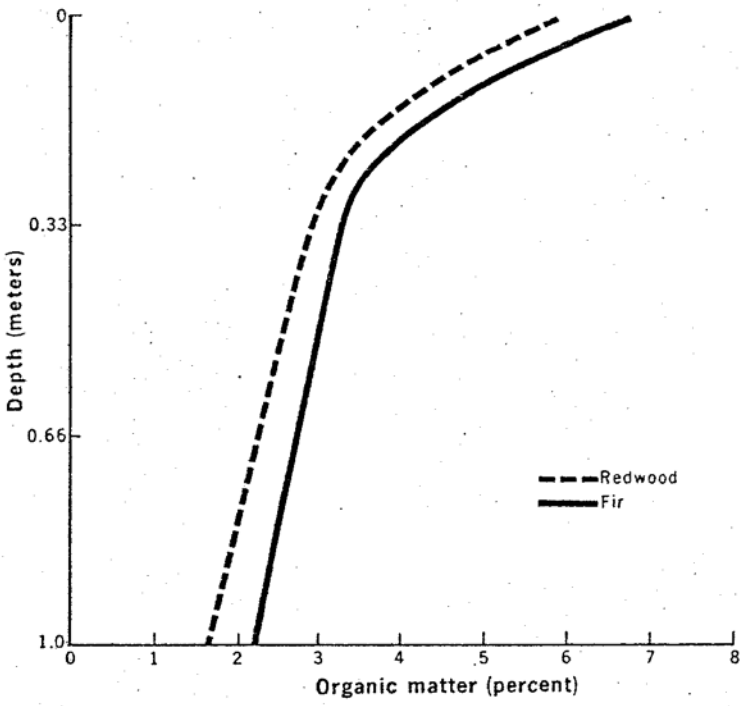

Figure 2—Organic matter content correlated with soil depth on the basis of depth and log depth variables. (R^2 = 0.75 for fir and 0.76 for redwood.)

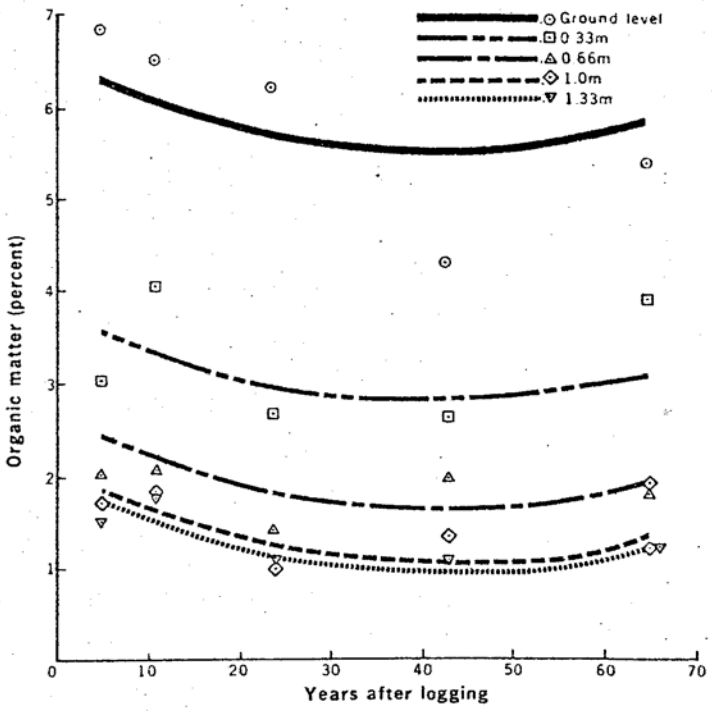

Figure 3—Percent organic matter compared to years after logging of redwood stands. The data points are averages of at least four samples, and no more than six.

tive to depth is similar in the redwood and fir zones (*fig. 2*).

Some of the variation in results, particularly those from the more widespread redwood locations, may be a consequence of stocking and site differences. Because each age class was collected from a different stand, this study could not separate age from location.

Maximum age after logging was 65 years in the redwood type compared to only 24 years in the fir. Although organic matter in the fir appeared to reach a minimum at 7 years, it was not statistically significant. The study, perhaps, did not consider old enough stands.

The redwood curves show a gradual decline in organic matter until 35 to 45 years after logging. Although this decline in organic matter is minor, its effects cannot be totally ruled out. Aggregation together with associated soil properties, shows its greatest response to change at low quantities of organic matter, particularly below 2 percent.[14] It is likely, however, that soil disturbance associated with logging has a greater impact. Tractors can churn-up the soil horizons and alter the long-term relationship of depth and organic matter in localized areas.

NOTES

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